UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
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OFFICE OF
WATER AND
WATERSHEDS

OCT 2 5 2018

Mr. Bill Lind
Southern Snake Branch Chief
NOAA Fisheries
800 E. Park Blvd., Plaza IV, Suite 220
Boise, Idaho 83712

DEPARTMENT OF COMMERCE
RECEIVED

26 Oct 2018

NATIONAL MARINE FISHERIES SERVICE
SNAKE BASIN OFFICE

Dear Mr. Lind:

The purpose of this letter is to confirm that the U.S. Environmental Protection Agency's proposed approval of Idaho's new and revised aquatic life selenium criterion complies with the reasonable and prudent alternatives (RPA) for selenium set forth in the National Marine Fisheries Service's May 7, 2014 Biological Opinion on Idaho's toxics water quality standards. Idaho's new and revised aquatic life selenium criterion went into effect under State law on March 28, 2018; however, the criterion is not effective for Clean Water Act purposes until approved by the EPA.

Enclosed is the EPA's analysis of Idaho's revised selenium aquatic life criterion that demonstrates consistency with the RPA. The EPA's analysis is based on the best available information, is consistent with the discussion and analysis in the Opinion, and completed in coordination with staff in your office.

The EPA looks forward to continuing our collaborative discussions with the National Marine Fisheries Service as we work with the State of Idaho to develop protective water quality criteria consistent with the Opinion. If you have any questions or would like to discuss further, please contact Lisa Macchio of my staff at (206) 553-1834 or Mark Jankowski at (206) 553-1476.

Sincerely,

Angela Chung

Angela Chung
Associate Director
Office of Water and Watersheds

Enclosure

cc: Mr. Michael Tehan, NMFS
Mr. Don Essig, DEQ

Analysis of the consistency of the Idaho Se water column criterion with the Services Se RPA

Attachment 1

Contributors: Summary statistics conducted in R by Tony Olsen. Write-up including subsequent analysis and interpretation by Mark Jankowski. Additional analysis for the Services by Chris Mebane.

Introduction

Both of the 2014[1] and 2015[2] biological opinions (BOs) for Idaho water quality standards developed RPAs for selenium (Se) concentrations in fish tissue and water. The calculated protective whole-body fish tissue value was 7.6 mg/kg dw. Using this value, the Services employed mechanistic modeling similar to Presser and Luoma (2010)[3] (a *method* that was modified, then incorporated by EPA into Appendix K of the EPA 2016 304(a) Se criterion[4], and adopted into rule by Idaho in 2018[5]), to calculate a protective water column criterion concentration of 2.0 µg/L as a geometric annual mean. Idaho adopted EPA's nationally recommended lotic water column concentration, which is a monthly arithmetic mean of 3.1 µg/L not to be exceeded more than once in three years in waters containing ESA listed salmonids and sturgeon (see Figure 1). Given the above differences, the EPA evaluated Idaho's lotic water column criterion to determine if it is consistent with the discussion and analysis in the BOs.

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[1] Biological Opinion for Water Quality Toxics Standards for Idaho, May 7, 2014. National Marine Fisheries Service. NMFS No: 2000-1484

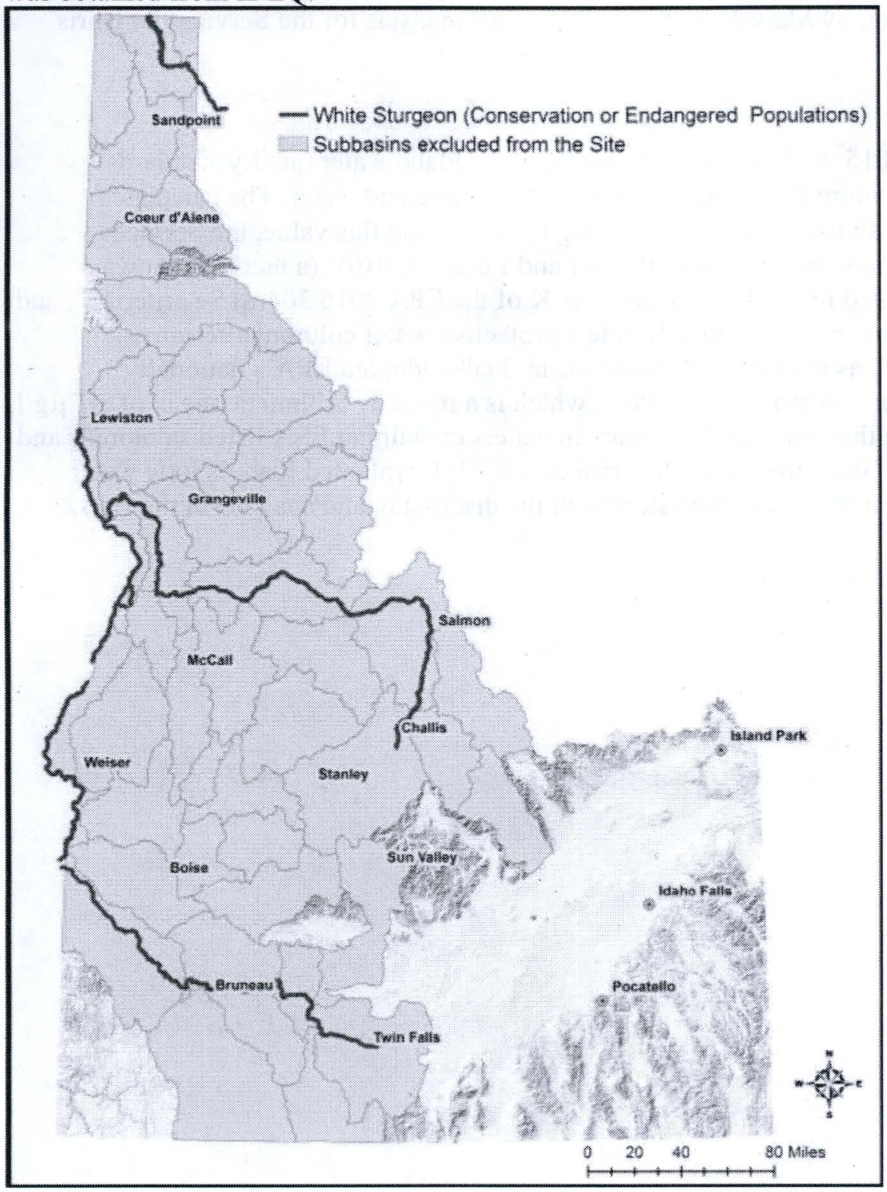
[2] Biological Opinion for Water Quality Standards for Numeric Water Quality Criteria for Toxic Pollutants, June 25, 2015. U.S. Fish and Wildlife Service. FWS No: 01EIFW00-2014-F-0233.

[3] Presser, T. S., and S. N. Luoma. 2010. A methodology for ecosystem-scale modeling of selenium. Integrated Environmental Assessment and Management **6**:685-710.

[4] https://www.federalregister.gov/documents/2016/07/13/2016-16585/recommended-aquatic-life-ambient-water-quality-criterion-for-selenium-in-freshwater

[5] http://www.deq.idaho.gov/58-0102-1701

Figure 1. Map of locations where Idaho's Se water quality standard applies. Subbasins shaded in salmon are managed under Idaho's standard and excluded from any site specific standards. Map was obtained from IDEQ.



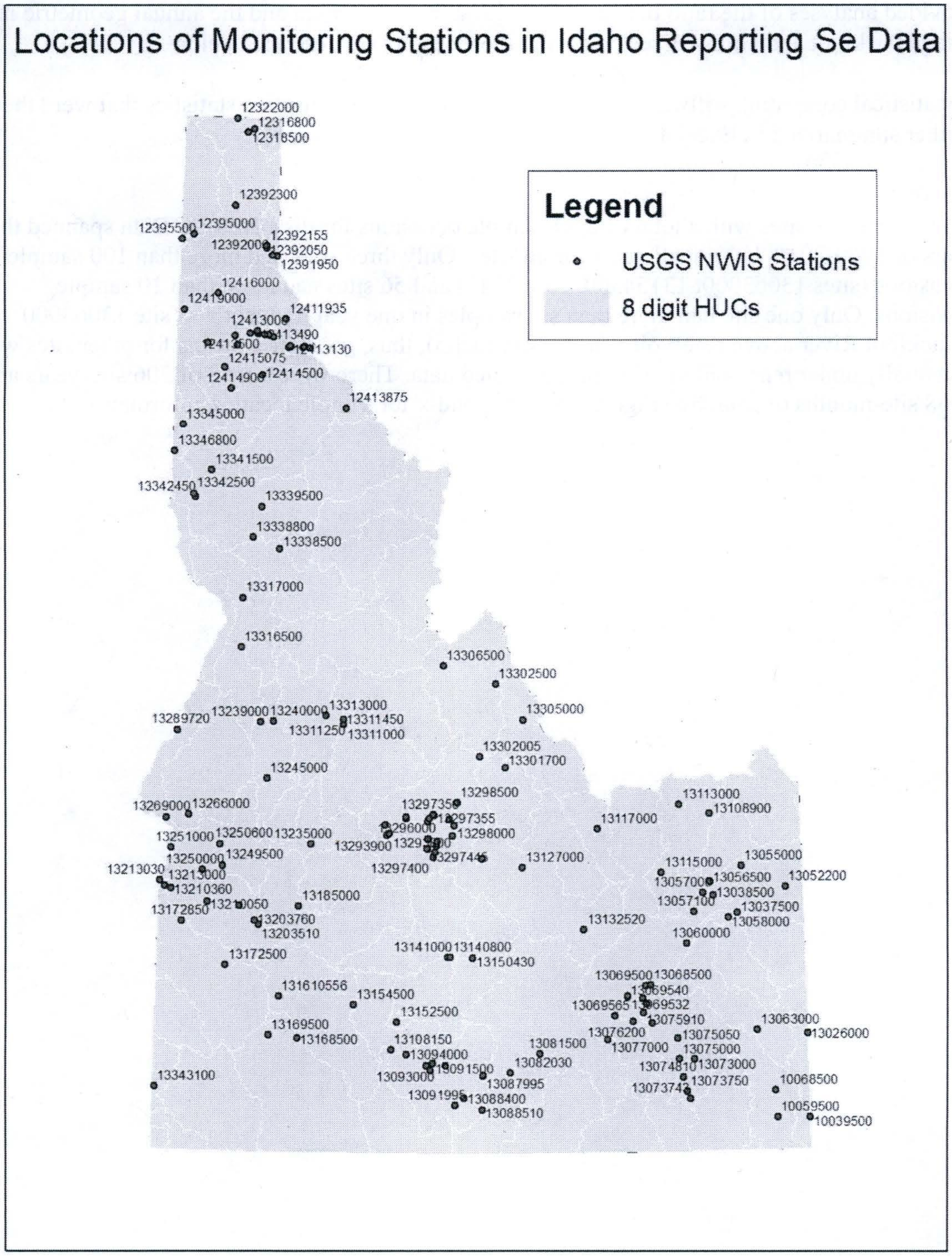
Methods

EPA used existing monitoring data in Idaho to determine if a once in three-year exceedance of a monthly average 3.1 µg/L was similarly or more stringent than an annual geometric mean of 2.0 µg/L in that dataset. If true, it could be concluded that the Idaho standard is in accordance with the FWS and NOAA biological opinion RPAs. EPA assembled available Se data from USGS NWIS on April 30, 2018 and from what was provided to EPA by NOAA on April 17, 2018. The former data included USGS monitoring stations while the latter included data from Grouse Creek Mine. The latter data primarily consisted of values that were less than the detection limits, and even for those that were greater than the detection limits, these exhibited very little variation (e.g., some were integer values). Therefore, EPA determined that these data were of secondary utility the its analyses and chose to focus its analysis on NWIS data. However, the Services provided analyses of the ratio between the highest 30d maximum and the annual geometric mean using Blackfoot and Grouse Creek data and these results are described below.

R statistical computing software was employed to produce descriptive statistics that were then further summarized in Excel as below.

Results
There were 142 sites with a total of 2768 sample occasions for dissolved Se. Data spanned the years of 1969-2018, but not all years for all sites. Only three sites had more than 100 sample occasions (sites 13063000, 13154500, 13092747) and 56 sites had more than 10 sample occasions. Only one site had more than six samples in one year and that was site 13063000 (Blackfoot River above reservoir near Henry, Idaho), thus, geometric means for other sites were potentially under representative given the limited data. There were a total of 706 site-years and 2068 site-months of data. See Figure 1 and Appendix for sample location information.

Figure 1. Map of USGS stations reporting Se data as of April 30, 2018. Note that not all sites were used for this analysis.



Analysis of the consistency of the Idaho Se water column criterion with the Services Se RPA

FREQUENCY WITH WHICH THE RPA AND IDAHO STANDARD ARE SIMILAR

The number of exceedances of the RPA annual criterion were tallied and are shown in Table 1. The number of exceedances of the Idaho monthly standard are shown in Table 2. There was a higher percentage of violations of the RPA (8.4% of samples) than of the Idaho standard (6.4% of samples. However, the opposite trend occurred when using only sites with greater than 6 months of data per year (the RPA was exceeded at a rate of 32.4%) or assessed during a period of three consecutive calendar years (the Idaho standard was violated at a rate of 34.3%). This latter observation suggests that the Idaho standard may be at least as stringent as a whole than the RPA. Because the above is not a complete resolution to the question posed in this document, further analyses were conducted to examine the relative stringency of the RPA and Idaho standard.

Table 1. RPA exceedances (>2.0 μg/L annual geometric mean)

Category	Exceedances	N, total	% violations
Site-years	59	706	8.4
Sites	32	142	22.5
Site-years (>6 months data)	12[1]	37	32.4

Notes: [1]site #13063000

Table 2. Idaho standard exceedances (> 3.1 μg/L monthly arithmetic mean more than once in three years)

Category	Exceedances	N, total	% violations
Site-months	132	2068	6.4
Sites	37	142	26.0
3-year period	369	1075	34.3

EPA next determined how often conclusions of "attainment" based on the Idaho standard matched conclusions based on the RPA. That is, false negative and false positive rates relative to the RPA were calculated from data found in Table 3. A "true" result for the purposes of the current analysis is based on comparisons to the RPA. A "false" result for the purposes of the current analysis is based on comparisons to the Idaho standard. This labeling convention is intended to simplify the language to align with the analyses used rather than refer to the true nature of things. However, it is worth noting that making comparisons to the RPA is appropriate as EPA does generally defer to the Services when it comes to an analysis of what is protective for ESA Listed species. That noted, a false negative here is defined as an occurrence in which the Idaho standard was not exceeded but the RPA was (3 times, see table 3). A false positive is defined as an occurrence in which the Idaho standard was exceeded but the RPA was not (18 times, see table 3). True positives and true negatives are occurrences in which the RPA was (59 times) or was not (647 times) exceeded, respectively.

Table 3. 2x2 contingency table for the number of occurrences of each of the four possible conditions based on 706 site-year combinations where Se data were available.

Contingency Table for Number of Occurrences by Condition	Result > RPA[2]	Result < RPA
Result > Idaho standard[1]	56	18 (false positives)
Result < Idaho's standard	3 (false negatives)	629
	59 true positives[3]	647 true negatives[4]

Notes:
[1]3.1 µg/L monthly arithmetic mean, once in one-year occurrence (keep in mind that a once in one year frequency threshold vs a once in three year threshold is a conservative, species protective approach)
[2]2.0 µg/L, annual geometric mean
[3]occurrences in which there was an RPA exceedance
[4]occurrences in which there was not an RPA exceedance

- False Negative Rate = 3/59 × 100 = 5.1%
- False Positive Rate = 18/647 × 100 = 2.8%

The false negative rate of 5.1% indicates that ~95 times out of 100 occurrences, a site with a violation of the Idaho criterion also violated the RPA. As an additional way of assessing the data, there were only 3 of 706 site-year combinations in which an annual violation occurred when a monthly violation did not; this represents 0.42% of the data. In contrast, there were 18 of 706 site-year combinations in which a monthly violation occurred but an annual did not; this represents 2.55% of the data. Together, these analyses suggest a relatively low likelihood that the Idaho standard would be less protective than (not consistent with) the RPA.

EPIDEMIOLOGICAL APPROACH TO ANALYZING FREQUENCY OF THE DIFFERENCE BETWEEN THE RPA AND IDAHO STANDARD

Epidemiology provides standardized metrics for our assessment because epidemiology is interested in the accurate detection rates of affected entities to properly apply limited resources. For the current analysis, EPA was interested in whether an exceedance of the Idaho standard would detect an RPA exceedance reasonably well. Two related metrics were calculated below.

- Sensitivity = number of true positives ÷ (number of true positives + number of false negatives)
  - Measure of a test's ability to correctly identify a non-compliant site.
- Specificity = number of true negatives ÷ (number of true negatives + number of false positives)
  - Measure of a test's ability to correctly identify a compliant site.

Using the data from the 2x2 table above:

Sensitivity
59 ÷ (59+3) = **0.95**
Sensitivity refers to the test's ability to correctly identify a non-compliant site. For the current analysis, sensitivity is being used to quantify the ability of a 3.1 µg/L monthly standard to

"correctly" identify a location that is not compliant with the 2.0 µg/L annual standard. Thus, based on the data, 95 out of 100 times where a 30-day average Se concentration was >3.1 µg/L, the geometric annual mean would be expected to be greater than 2.0 µg/L.

Specificity
647 ÷ (647+18) = **0.97**
Specificity is a measure of a test's ability to correctly identify a compliant site. For the current problem, specificity is being used to quantify the ability of a 3.1 µg/L monthly standard to correctly identify a location that is compliant with the 2.0 µg/L annual standard. Thus, based on the data, 97 out of 100 times where a 30-day average Se concentration was <3.1 µg/L, the geometric annual mean would be expected to be less than 2.0 µg/L.

Sensitivity is most important to optimize if non-BO-compliance indicates high risk to species. Specificity is most important to optimize when non-BO-compliance indicates elevated but not high risk to species and falsely applying a remedy is resource intensive. For these reasons, EPA is most focused on the sensitivity result of 0.95 as well as the false negative rate of 5.1%. Both of these values suggest that 3.1 µg/L may be stringent enough to detect non-compliant sites (i.e, to prevent exceedance of 2.0 µg/L geometric annual mean).

MAGNITUDE OF DIFFERENCE BETWEEN THE RPA AND IDAHO STANDARD
The above delves into differences in the capacity to detect an RPA violation in a site-year. The following describes the magnitude of RPA exceedance for occasions when the Idaho standard is not exceeded. This analysis is focused on site 13063000 because that is where the majority of data reside and so it was possible to conduct this analysis on a site-3 year basis instead of a site-year basis as the above. However, there were no occasions in which the true once in three-year Idaho standard or a theoretical (conservative) once in one year Idaho standard was complied with but the annual geo mean RPA was not. There was one year (2015), however, in which the RPA was not exceeded but the Idaho standard was. In 2015, April exhibited a monthly average of 3.18 µg/L while the annual geo mean was 1.91 µg/L.

The Services conducted an additional analysis of the relationship between the Idaho standard (3.1 µg/L Se, 30-day average one exceedance in a three-year period) and the RPA (no exceedance of 2.0 µg/L Se annual geometric mean). The focus of this analysis was on the magnitude of the difference between the two benchmarks. The analysis was focused on the Blackfoot River in SE Idaho because it has a rich dataset for this type of analysis. Although it's not in the action area, it provides abundant real data on a real stream. Most of the data are from a flow-triggered autosampler, so it characterizes high flow/high concentration periods well. There were over 600 measurements from 2001-2016 with no nondetects. The ratio of the 30d max (from a rolling 30-day average) to the annual geomean within the same year was 1.9 from 2008 to 2017 (Table 4). And, given that 1.9 x 2 = 3.8 (µg/L), the data suggest that both the RPA and Idaho standard would indicate an exceedance (i.e., a consistent conclusion would be reached). Similar calculations for some of the lowest and highest Se on record there (2012 and 2013) gave ratios of 1.5 to 2.3. See Figure 3 for further information.

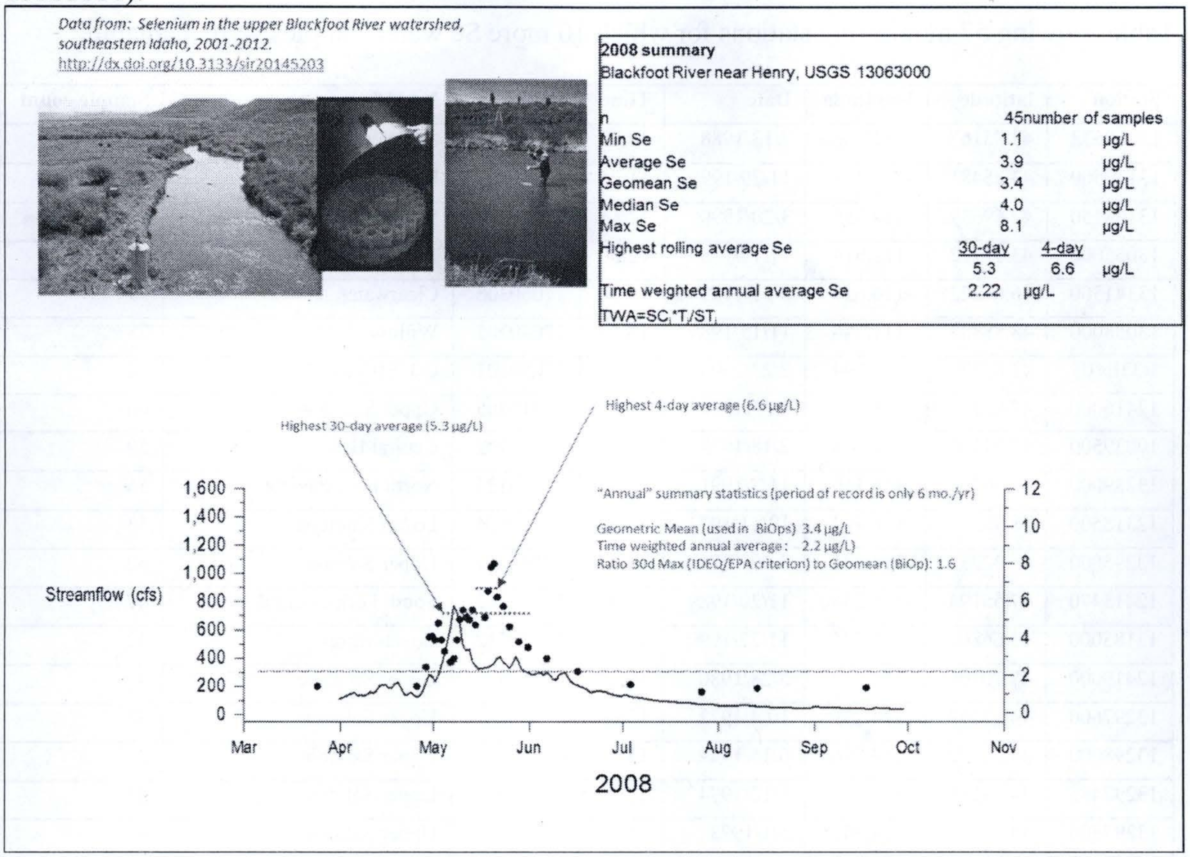
Table 4. Ratio between rolling 30-day maximum Se concentration (µg/L) and the annual geometric mean by year on the Blackfoot River (USGS station 13063000)

Ratio 30d/annual geomen	
2017	1.8
2016	2.1
2015	1.9
2014	2.1
2013	2.3
2012	1.5
2011	1.9
2010	1.5
2009	2.3
2008	1.6
10yr Average (2008-2017)	**1.9**

The Services also assessed Thompson Creek data for one site, TC1, a site that is their most downstream sampling location on Thompson Creek that is downstream of all mine discharge. It was considered most likely to be used by anadromous fish. The average 30d to geomean ratio was 1.8, with a range of 1.4 to 2.3 for the 9 years for which there were data. These Thompson Creek data are good because they are in the action area. However, they are only reported to the integer level and have a high (1 µg/L) detection limit, which makes ratios erratic on years with few data. A concentration of 0.5 µg/L was assumed for nondetects, as that's the lowest value ever measured in the lower Blackfoot and considered to be a reasonable estimate for background.

These analyses indicate that because the 30d average:annual geomean ratios are generally > 1.6, an exceedance of the RPA of 2.0 µg/L would also tend to equate to an exceedance of the Idaho standard of 3.1µg/L. Thus, EPA finds additional evidence to conclude that the Idaho standard is consistent with the RPA.

Figure 3. Summary of Se water concentrations at the Blackfoot River monitoring site (USGS 13063000).



Summary

EPA's results of its analysis of available Se monitoring data in Idaho include:

- A higher frequency of RPA exceedances (32.4%) than Idaho standard (34.3%) exceedances
- False negative detection rate of 5.1%, suggesting that the RPA was more stringent than the Idaho standard 94.9% of the time
- A high capacity of the Idaho standard to detect an RPA exceedance as shown by a sensitivity of 0.95.
- The site with greater than 6 months of data (Blackfoot River) per year never experienced an RPA exceedance while not experiencing an Idaho standard exceedance. Please find additional analysis comparing the magnitude of each benchmark in the Appendix.
- A ratio between the rolling 30d average and the annual geometric mean within a year of 1.9, indicating that an annual geomean of 2.0 µg/L is associated with a 30d maximum of 3.8 µg/L (meaning that comparisons of Se water concentration data to either benchmark would lead to the same conclusion of an exceedance, a conclusion protective of Listed species)

For these reasons, EPA concludes that the Idaho standard based on EPA's 304(a) recommended Se criteria is consistent with USFWS and NOAA BO's.

Appendix

Table showing 57 monitoring stations for which 10 more Se water samples were available.

Station	latitude	longitude	Date	Time	HUC8	NAME	Sample count
13069532	43.05167	-112.686	7/13/1988	14:00	17040206	American Falls	667
13172500	43.25481	-116.391	11/29/1990	11:25	17050103	Middle Snake-Succor	157
13108150	42.69639	-114.855	3/20/1990	12:15	17040213	Salmon Falls	130
13055000	43.92722	-111.614	11/17/1989	12:00	17040204	Teton	79
13341500	46.61222	-116.658	5/21/1980	14:30	17060306	Clearwater	79
13058000	43.58333	-111.746	11/15/1989	13:00	17040205	Willow	78
1.32E+08	43.05028	-115.894	2/23/2000	3:30	17050101	C.J. Strike Reservoir	72
12416000	47.8225	-116.655	3/25/1980	11:00	17010305	Upper Spokane	66
10039500	42.21104	-111.054	2/18/1978	15:15	16010102	Central Bear	59
13239000	44.90722	-116.119	11/7/1991	8:15	17050123	North Fork Payette	56
12318500	48.905	-116.402	12/11/1973	9:15	17010104	Lower Kootenai	53
13295000	44.2225	-114.931	8/30/1971	10:45	17060201	Upper Salmon	52
12413470	47.55194	-116.236	11/20/1989	14:00	17010302	South Fork Coeur d'Alene	47
13185000	43.66806	-115.725	11/27/1990	11:30	17050112	Boise-Mores	42
12419000	47.70306	-116.978	5/28/1980	10:30	17010305	Upper Spokane	40
13297600	44.15297	-114.299	10/4/1972	13:00	17060201	Upper Salmon	36
13298000	44.22472	-114.286	6/15/1972	13:10	17060201	Upper Salmon	32
13297485	44.13158	-114.53	6/12/1974	10:30	17060201	Upper Salmon	31
13297500	44.11528	-114.441	5/1/1973	11:40	17060201	Upper Salmon	31
13298500	44.37853	-114.256	7/24/1972	15:30	17060201	Upper Salmon	31
12413500	47.5547	-116.323	11/12/1986	12:00	17010303	Coeur d'Alene Lake	30
13026000	42.78326	-111.054	10/10/1989	11:35	17040105	Salt	28
13038500	43.73528	-111.878	11/21/1989	14:30	17040201	Idaho Falls	26
12391950	48.08806	-116.073	11/13/1989	10:15	17010213	Lower Clark Fork	24
12392000	48.09167	-116.117	11/13/1989	10:15	17010213	Lower Clark Fork	24
13069540	43.0588	-112.691	10/20/1987	14:45	17040206	American Falls	24
13213000	43.78167	-116.973	3/20/1974	13:00	17050114	Lower Boise	24
12413000	47.5722	-116.253	5/21/1980	13:30	17010301	Upper Coeur d'Alene	23
12322000	48.99639	-116.507	11/9/1983	11:30	17010104	Lower Kootenai	19
13069565	42.92408	-112.811	10/20/1987	11:50	17040206	American Falls	17
13076200	42.88602	-112.642	10/20/1987	8:30	17040206	American Falls	15
13069500	43.12528	-112.519	6/12/1976	10:40	17040206	American Falls	14
10059500	42.21659	-111.344	7/15/1976	12:15	16010201	Bear Lake	13
12392050	48.13798	-116.18	1/28/1970	15:40	17010213	Lower Clark Fork	13
12395000	48.21972	-116.914	5/23/1980	12:00	17010215	Priest	13
13075910	42.94472	-112.544	10/22/1987	14:30	17040208	Portneuf	13
13293800	44.1638	-114.887	7/17/1978	13:00	17060201	Upper Salmon	13

13313000	44.96167	-115.5	11/6/1991	10:10	17060208	South Fork Salmon	13
13346800	46.73194	-117.024	5/22/1980	9:20	17060108	Palouse	13
12395500	48.18222	-117.034	11/26/1990	10:25	17010216	Pend Oreille	12
13056500	43.82583	-111.905	8/19/2014	10:50	17040203	Lower Henrys	12
13075983	43.0425	-112.55	10/22/1987	11:00	17040208	Portneuf	12
13087995	42.52806	-114.018	11/21/1990	11:00	17040212	Upper Snake-Rock	12
13088510	42.29408	-114.023	4/7/1993	15:00	17040212	Upper Snake-Rock	12
13092747	42.5625	-114.495	12/17/2013	10:10	17040212	Upper Snake-Rock	12
13108900	44.2888	-111.895	11/13/1990	14:15	17040214	Beaver-Camas	12
13113000	44.35528	-112.18	3/21/1995	11:30	17040214	Beaver-Camas	12
13115000	43.89139	-112.358	9/10/1985	11:00	17040214	Beaver-Camas	12
13154500	43.00222	-115.203	6/16/1975	11:15	17050101	C.J. Strike Reservoir	12
13251000	44.04222	-116.925	11/21/1989	11:45	17050122	Payette	12
13302500	45.18361	-113.895	11/7/1991	9:15	17060203	Middle Salmon-Panther	12
13305000	44.94	-113.639	3/9/1992	14:00	17060204	Lemhi	11
12392155	48.15167	-116.182	9/2/1999	9:45	17010213	Lower Clark Fork	10
13297355	44.29083	-114.472	5/3/1973	16:05	17060201	Upper Salmon	10
13297404	44.03908	-114.462	10/4/1972	11:15	17060201	Upper Salmon	10
13297440	44.05825	-114.533	7/10/1974	9:30	17060201	Upper Salmon	10
13297480	44.12964	-114.524	7/18/1972	14:00	17060201	Upper Salmon	10

Attachment 2

Reconciliation of the Whole-body Selenium Tissue Thresholds Derived in the NMFS 2014 Biological Opinion and the 2016 EPA Selenium Aquatic Life Criterion

By Chris Mebane, U.S. Geological Survey

Without regard to procedural matters, there is a key question to reconcile between the proposed Idaho adoption of the 2016 U.S. Environmental Protection Agency (EPA) selenium (Se) aquatic life criteria (ALC) and data described in the NOAA's National Marine Fisheries Service's (NMFS) Biological Opinion (hereinafter referred to as "Opinion")(NMFS 2014): *Is the EPA 8.5 mg/kg whole body criteria close enough to the NMFS estimate of 7.6 mg/kg whole body value to be considered consistent with the Opinion?*

Issues Considered for the NMFS Opinion

The reasons for differences between the EPA and NMFS "safe" estimates of whole body Se values in fish tissue are twofold. First, the Opinion preceded both the EPA's 2014 draft or 2016 final national aquatic life criteria document (EPA 2016). Second, the 2016 criteria were derived using concentrations causing a 10 percent effect (EC_{10}) for reproductive effects only. The reproductive effects occur as result of maternal exposures. The Opinion ignored reproductive effect values, on the assumption that adult anadromous fish returning from the ocean to freshwater to spawn likely obtained their Se exposure somewhere else, since Se exposures are predominantly from diet and since anadromous salmon tend not to feed much in freshwater during their spawning migrations.

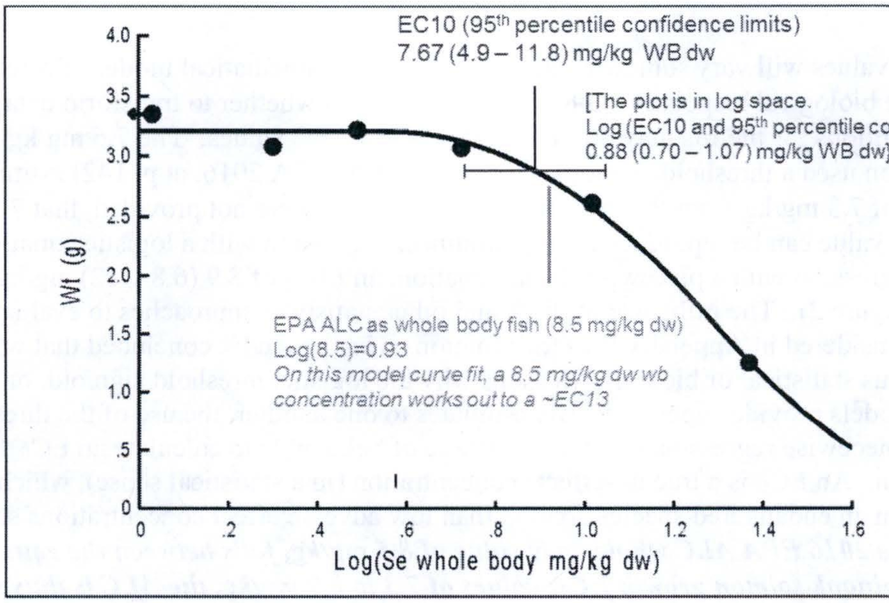
The Opinion focused on potential growth or survival effects from Se to juvenile salmon and steelhead in freshwater. One study was particularly relevant for this question, in which juvenile Chinook salmon were fed pellets spiked with Se in one of two ways (Hamilton et al. 1990). In one dietary exposure method, the "SeMe diet," the feeding pellets were made using a ground up, freeze dried mosquitofish diet from a "clean" reference site, fortified with laboratory grade selenomethionine (SeMe). The second diet was the same, except instead of adding laboratory grade SeMe, fish were collected from an irrigation wastewater drainage ditch called the San Luis Drain (SLD) in the Central Valley of California that had elevated concentrations of at least Se, boron, and strontium (Hamilton et al. 1990). The results of the tests using the mixed SLD diet showed reduced growth in all Se treatments, even at very low doses. This suggested that some contaminants other than Se might present in the SLD wastewater, and the apparent effects might not all be from Se. No farm chemicals such as pesticides were measured. Thus, data quality for the results from the SLD diet experiment were considered unreliable. NMFS focused on the results of the "pure" SeMe test only; the SLD test was considered a site-specific mixture and was not relied upon.

Using the SeMe results, an EC_{10} for growth as weight was considered a low-effects threshold for Se. NMFS calculated an EC_{10} estimate of the 7.6 mg/kg (dry weight [dw]). Like all effect concentration (EC) values, this EC_{10} estimate has uncertainty associated with it. Commonly, the 95th percentile upper and lower confidence intervals are associated with EC values, which can roughly be interpreted as a 95 percent probability that the "true" EC_{10} value lies between these bounds, at least for the particular model choices used. For the EC_{10} value of 7.6 mg/kg, the associated 95th percentile confidence limits were 4.9 to 11.8 mg/kg (Figure 1). Applying EPA's

ALC of 8.5 mg/kg value to that same curve fit, would produce about a 13 percent weight reduction or an EC_{13} value. In other words, the projected effects to Chinook salmon growth reductions associated with the Opinion 7.6 mg/kg value and the EPA 8.5 mg/kg ALC value are similar.

Further, EC values will vary somewhat depending on the mathematical model selected to represent the biological responses. Other decisions such as whether to transform data, and starting conditions for the fits may produce quite different EC values. The 7.6 mg/kg EC_{10} value in the Opinion used a threshold sigmoid regression. EPA (EPA 2016, at p. 142) estimated an EC_{10} value of 7.3 mg/kg from the same data. While details were not provided, that 7.3 (4.6 – 11.8) mg/kg value can be reproduced using nonlinear regression with a logistic equation. Using nonlinear regression with a piecewise linear equation, an EC_{10} of 8.9 (6.8 – 12) mg/kg is produced (Figure 2). The influence of these and other statistical approaches to evaluating effects data were considered in Appendix B of the Opinion. That appendix concluded that while there are no obvious statistical or biological reasons why the logistic, threshold sigmoid, or piecewise nonlinear models provide superior effects estimates to one another, the use of the threshold sigmoid or piecewise regression had the advantage of being able to calculate an EC_0 concentration. An EC_0 is a true no-effects concentration (in a statistical sense), which is easier to interpret in an endangered species context than low adverse effect concentrations such as an EC_{10}. ***As the 2016 EPA ALC whole body value of 8.5 mg/kg, falls between the equally plausible Chinook salmon growth EC_{10} values of 7.3 to 8.9 mg/kg, the ALC is thus statistically indistinguishable from the Opinion EC_{10} value.***

Se.chinook.wt.60d.SeMe.Hamilton.1990



Parameter Summary (Threshold Sigmoid Regression Analysis)

Parameter	Guess	FinalEst	StdError	95%LCL	95%UCL
LogX50	1.3148	1.2871	0.0268	1.2017	1.3725
S	0.6971	1.3758	0.1861	0.7836	1.9679
Y0	3.217	3.207	0.066	2.998	3.416

Effect Concentration Summary

%Effect	Xp Est	95%LCL	95%UCL
50.0	19.369	15.912	23.578
20.0	10.470	7.645	14.340
10.0	7.679	4.992	11.813
5.0	6.167	3.633	10.471

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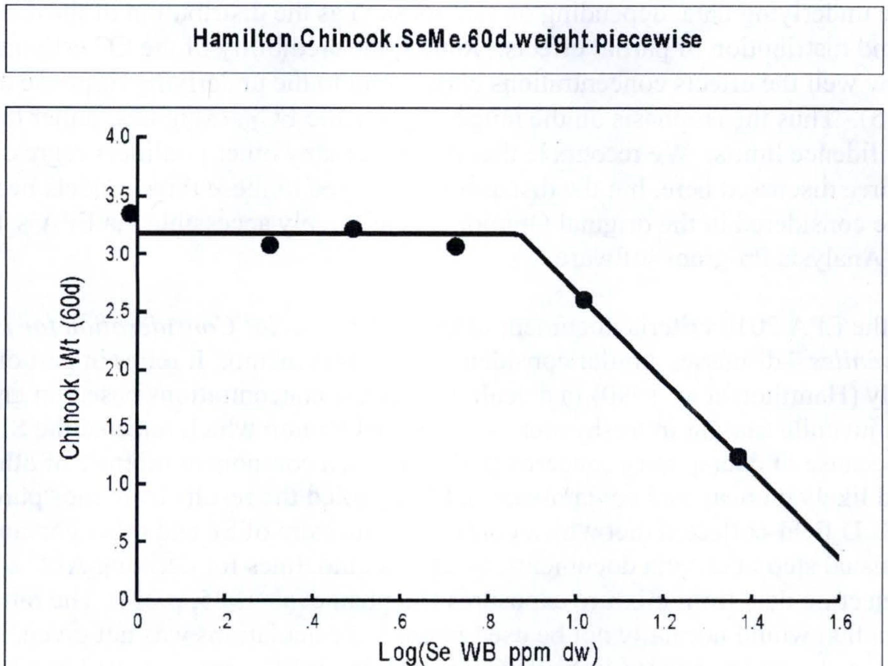
Figure 1. A 10 percent reduction in weight for juvenile Chinook Salmon exposed to dietary was used as a low-effect threshold in the NMFS Opinion. While independently obtained, this estimate is similar to the 8.5 mg/kg 2016 whole-body aquatic life criteria. The Xp is the effect concentration (EC) values for a given % effect. Data from Hamilton et al.'s (1990) 60-day feeding trials with selenomethionine. Overlay lines were drawn by hand and are not exact.



Parameter Summary (Piecewise Linear Regression Analysis)

Parameter	Guess	FinalEst	StdError	95%LCL	95%UCL
LogX50	1.2895	1.2812	0.0284	1.1907	1.3717
S	1.4564	1.2144	0.1691	0.6762	1.7525
Y0	3.180	3.180	0.066	2.969	3.391

Effect Concentration Summary

%Effect	Xp Est	95%LCL	95%UCL
50.0	19.106	15.513	23.532
14.0	9.654	7.183	12.976
10.0	8.949	6.486	12.348
5.0	8.140	5.699	11.626
0.0	7.403	5.000	10.961

08/12/2017 19:43 MED Toxicity Relationship Analysis Model, Version 1.30

Figure 2. The same data in Figure 1 can be fit equally well using a piecewise regression model, producing a Se EC_{10} of 9 mg/kg whole body dw. The U.S Environmental Protection Agency aquatic life criteria of 8.5 mg/kg falls between the different EC_{10} values for reduced growth in Chinook salmon.

The range of plausible EC values is used as the test of similarity rather than the statistical confidence limits of each estimate. This follows complaints that sometimes little confidence should be placed in statistical confidence limits, as they can be misleadingly narrow or wide in relation to the underlying data, depending on factors such as the distribution of the data, number of samples, and distribution of partial effects. Rather, the credibility of the EC estimates can be judged by how well the effects concentrations correspond to the underlying response data (Mebane 2015). Thus the emphasis on the range of plausible EC_{10} estimates, rather than their statistical confidence limits. We recognize that there are many other nonlinear regression models beyond the three discussed here, but the discussion is limited to these three models because these were the three considered in the original Opinion and are freely accessible via EPA's Toxicity Relationship Analysis Program software.

A section of the EPA 2016 criteria document titled "*6.4.1. Special Consideration for Pacific Salmonid Juveniles,*" discusses similar considerations as this memo. It relies in part on the same Chinook study (Hamilton et al. 1990) in calculating effects concentrations based on growth reductions of juvenile salmon in freshwater. Unlike the Opinion which rejected the SLD experiment because of data quality concerns (Se dose was a component mixture of other measured and likely unmeasured contaminants), EPA pooled the results from the "pure" SeMe test and the SLD field-collected diet which contained a mixture of Se and other contaminants. This is an unusual step in criteria documents, as EPA's guidelines for deriving ALC specifically require for rejecting data from mixture exposures (Stephan et al. 1985, p.22). The rationale for including data that would normally not be used in criteria calculations was not given, but by doing so produced a recommended juvenile Chinook salmon EC_{10} estimate (9.1 mg/kg dw) for special consideration for Pacific salmonid juveniles that was greater than the 8.5 mg/kg whole body tissue criterion. EPA calculated the 9.1 mg/kg value as the geometric mean of the pure SeMe diet EC_{10} (7.3 mg/kg) and the mixed contaminants SLD diet EC_{10} (11.1 mg/kg dw). Interestingly, when evaluating and rejecting the SLD mixture test as a line of evidence in the Opinion, NMFS calculated an EC_{10} of 4.6 mg/kg as opposed to the 11.1 mg/kg EC_{10} calculated by EPA (Opinion, p. 174; ALC document, p. 144) (Figure 3). The EC_{10} values are very different because the curve fit performed for the Opinion (Figure 3, Panel A) estimated a 10 percent reduction from close to the control, but the curve fit performed for the ALC (Figure 3, Panel B) effectively ignores the control and estimates a 10 percent reduction from the nearly flat section of the curve. In the Opinion, the responses from this test were considered unreliable; therefore, the study was not relied upon because all responses were lower than the controls, but did not further decline as a function of Se except in the higher treatment. This suggested that the test should be considered compromised as a Se test in that something other than Se was contributing to the effects. However, in the EPA analyses, this test was given equal footing as a companion test using a diet fortified with pure SeMe. These different nonlinear regression solutions and decisions about data validity account for the differences between the Opinion and EPA ALC values to protect juvenile Pacific salmon.

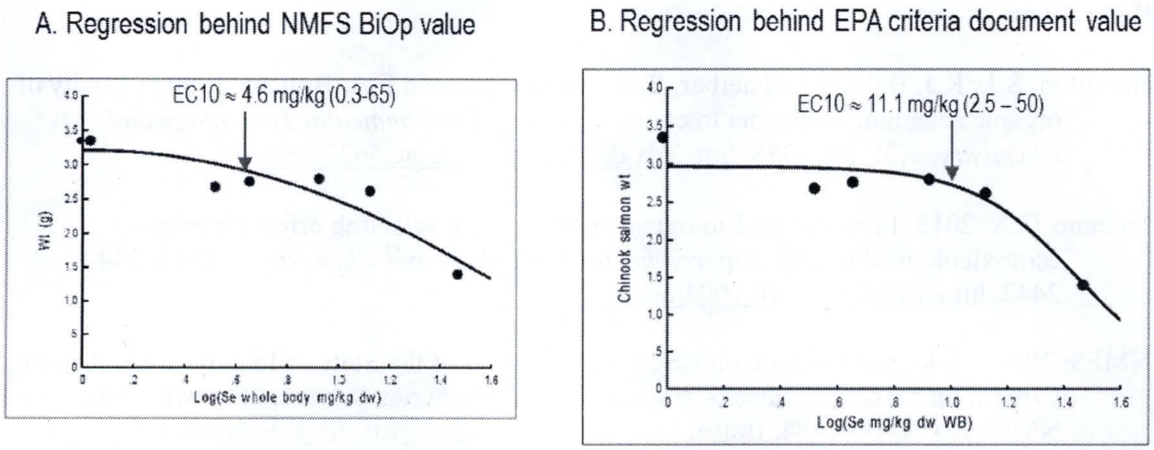


Figure 3. **Logistic regressions of juvenile Chinook salmon growth reductions fed a diet made using ground up mosquitofish collected from the San Luis Drain, California containing elevated boron, molybdenum, and selenium (Hamilton et al. 1990). Although using the same data, the logistic regressions converged to different curves (non-unique solutions) depending on the starting values. In panel (A), the logistic regression solution that produced the 4.6 mg/kg dw EC_{10} mentioned in the Opinion did a reasonably good job fitting the control (lowest, leftmost point), but did not fit the other points well. In panel (B), the logistic regression solution that produced the 11.1 mg/kg dw EC_{10} used in the U.S. Environmental Protection Agency criteria did a poor good job fitting the control (lowest, leftmost point), but fit other points well.**

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